İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

INTERACTIVE EARTHQUAKE INFORMATION ON THE INTERNET

M.Sc. Thesis by
Aslı GARAGON, B.S.

Department : Geodesy and Photogrammetry Engineering

Programme: Geodesy and Photogrammetry Engineering

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PREFACE

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I thank my mother and my father for the opportunity given to accomplish my education, my brother Kurtuluş Garagon for his interest despite the distance, and my sister Aylin Garagon for her moral support at the last stage of this study.

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TABLE OF CONTENTS

ABBREVIATIONS

BMP	: Windows Bitmap
ESRI	: Environmental Systems Research Institute
EXE	: Executable File Extension
GIS	: Geographic Information System
GPS	: Global Positioning System
HTML	: Hypertext Transfer Markup Language
IMS	: Internet Map Server
IP	: Internet Protocol
ISDN	: Integrated Services Digital Network
JPEG	: Joint Photographics Experts Group
KOERI	: Kandilli Observatory and Earthquake Research Institute
MB	: Megabytes
MHz	: Megahertz
MO	: Map Objects
MOIMS	: Map Objects Internet Map Server
PC	: Personal Computer
RAM	: Random Access Memory
TCP	: Transmission Control Protocol
TIFF	: Tagged Image File Format
TXT	: Text File Format
URL	: Universal Resource Locator
USGS	: United States Geological Survey
WWW	: World Wide Web

LIST OF TABLES

LIST OF FIGURES

İNTERNET ÜZERİNDEN DEPREM BİLGİ SİSTEMİ

ÖZET

Bu projenin amacı, internet kullanıcılarının deprem bilgilerine kolay ulaşabilmelerini sağlamaktır. İnternet Üzerinden Deprem Bilgi Sistemi, konumsal data ve kullanıcı arasındaki etkileşimi ifade etmektedir. Çalışma, Coğrafi Bilgi Sistemi (CBS) ve İnternetin fonksiyonlarını birleştirmektedir.

Veri iletiminde İnternetin işlevi dar kapsamda, kullanıcıların veriyi İnternet üzerinden elde edip, kendi bilgisayarlarında özel CBS yazılımları ile değerlendirmeleri olarak düşünülmektedir. Bu yaklaşım, datanın daha verimli kullanılmak istendiği durumlar için anlamlıdır. Fakat bu durumda İnternetin işlevselliği sınırlandırılmaktadır, kullanıcılar veriyi görebilmek için özel CBS yazılımlarına ihtiyaç duymaktadırlar. Bu çalışma, İnternet üzerinden CBS verisini ve CBS fonksiyonlarını kullanabilmek için, yazılımdan bağımsız bir sistem sunmaktadır. Bilgiye ulaşabilmek için sadece bir İnternet tarayıcısı yeterli olmaktadır.

Böyle bir sistemi oluşturmak için, programlama yapmak ve bilgisayarda verileri işlemek gerekmektedir. Bu nedenle bir CBS uygulaması geliştirilmiş ve İnternet kullanıcılarının uygulamaya ulaşabilmelerini sağlamak amacı ile bir arayüz programı kullanılmıştır. Kullanıcılar bu sistem aracılığı ile konumsal ve tarihsel sorgulama yaparak, deprem bilgilerine ulaşabilmektedirler. Bu model, bilginin devamlılığı ve güncellenmesi de dahil olmak üzere veri yönetimini kolaylaştırmaktadır.

INTERACTIVE EARTHQUAKE INFORMATION ON THE INTERNET

SUMMARY

The aim of the project is to provide public access to information about earthquakes. "Interactive Earthquake Information on the Internet" is the interactivity of the users and the spatial data. The study combines the advantages of both GIS and the Internet.

Using the Internet to transmit data assumes that the user will run the data in their local machine with stand-alone GIS software installed. This is meaningful in the sense that it can facilitate users to obtain data more efficiently. However the meaning of the Internet in this manner is very limited. GIS users must have traditional GIS softwares to view and analyse data. This study serves a software-independent system to use online GIS. The Internet Browser is adequate only to reach the information.

In order to built such a system, it is required to program and process the data in a computer. So a GIS application is formed and a gateway program is used to communicate the users. Users can access earthquake information doing spatial and historical query by means of the system. Furthermore this model makes the producer have easy data management including maintenance and updating.

1. INTRODUCTION

1.1. Introduction and the Aim of the Study

It might be thought that the field of GIS is not a recent innovation. From the earliest civilizations to modern ones, spatial data have been collected by surveys and rendered into pictorial form. The demand for maps of the topography and specific themes of the Earth's surface has accelerated greatly in the twentieth century.

During the 1960s and 1970s, first examples of the earliest GIS - which is a computer based system that capture, store, edit, analyze, display, and plot geographically referenced data- were developed. But the system required development of technology, which was a very high cost. In the 1980s, as the computer technology improved and the hardware prices decreased, so GIS became a viable technology.

Modern GIS arrived when computers become powerful, more easy to use and more affordable (Davis, 96). In the early 1990s while the GIS technology improved, the Internet –which is a worldwide collection of computer networks, cooperating with each other to exchange data using a common software standard- has also closely followed the rapid development of the computer technology. File transfers have enabled the widespread distribution and retrieval of geographic data on the Internet.

Today approximately 40 million people who are in almost 150 countries around the world are connected to the Internet. From the nineteenth century called the Machine Age, the Internet takes us into the Information Age. It seems that all future applications of GIS will be web applications that run over the Internet.

In this thesis, it is aimed to comprehend and develop the existing study that is named Interactive Earthquake Information on the Internet, which provides an easy access information about earthquakes for the public users. It was designed to meet low technological requirements with inexperienced users. In this system, data prepared before and data formed after are used together. To provide maintenance and management for the existing application, the web site was redesigned with minor changes in the functions. Furthermore new layers were added to the map to extend the study.

In the second chapter, necessities for sharing data are mentioned, and the balance of the client/server model which the web is based are described. Furthermore, types of access to geographic information on the Internet are summarized.

In chapter three, there are detailed information about "Interactive Earthquake Information on the Internet" was explained. Methods, tools and data types used and work flow of the application are clarified.

Chapter four consists the steps of improvements in the project. Construction of the study and client side of the application are also included.

2. ACCESS TO GEOGRAPHIC INFORMATION

2.1 Information Sharing over the Internet

The advantages of the world wide web are numerous, the two primary being time independence and spatial independence (Mohler and Duff, 99). It provides easy access to data from different sources. People can request and download information from the web over the Internet. It is more efficient than transmitting data through disks. Without the web, sharing information would be slower and more complicated. Since the web is widespread, it is an efficient way to distribute data.

There are many benefits of sharing data. When the cost of "no information" is compared with the costs of sharing technologies, it is boldly seen that the costs of sharing technologies are cheap. Two components of the 1990s technologies, the Internet and GIS changed the processes of accessing, sharing, disseminating and analyzing data. Online GIS combines the advantages of both GIS and the Internet. It is described as a network-centric GIS tool that uses the Internet to access and transmit data and analysis tools to enhance the visualization and integration of spatial data.

2.2 Balance of the Process Sharing

For designing online GIS applications, variety of programs and forms are available. But the web applications are based on the same model that is called client/server model (Figure 2.1). The client makes a request to a server. The server processes the request and returns the information to the client. In this model, the process is shared between the client and the server, with different ratios. This sharing process is generated in various forms which have advantages and disadvantages. A thick client (interacting with a light server) provides powerful analysis. But it is hard to maintain the service. A thin client (interacting with heavy server) is limited with simple applications. However, it can be used by many people.

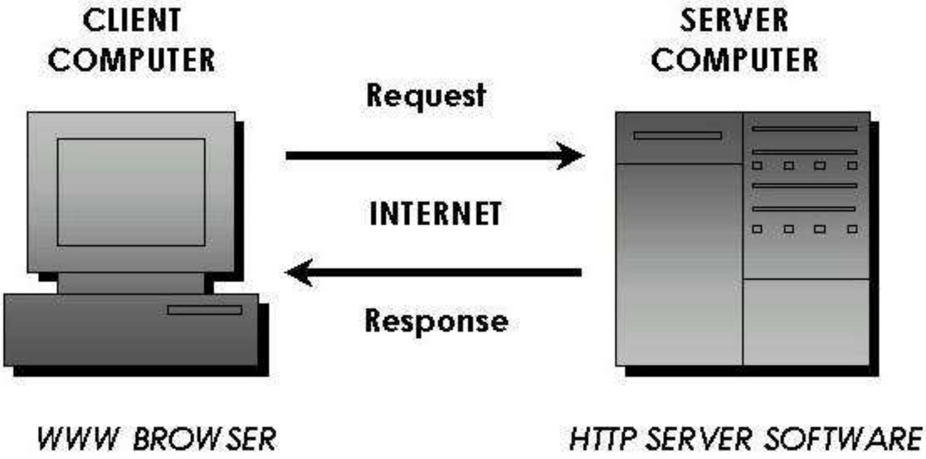


Figure 2.1 Classic Client/Server Model.

2.3 Approaches to Online GIS

Geographic information can be distributed in variety of forms on the Internet. Online GIS includes any application that uses the Internet technology to make geographic data available. There are four basic approaches to transmit geographic data.

2.3.1 Raw data

Types of access to geographic data depend on the requirements. Users can wish to use data in their own systems to analyse. The best choice for these users is to download the raw data over the Internet. After the data sets have been put on the user's local disk, the GIS work is done off-line. In this data distribution type, users must have their own GIS softwares. The user can do many operations, rather than sending a new request for every operation. Although the internal data structure of a GIS is generally too complex (i.e., many files and directories) to transport easily (Plewe, 97). FTP which stands for file transfer protocol has been a popular alternative to the Web for transporting this type of information. Software-specific formats and also software-independent exchange formats are available. In this type, there is little processing on either side.

2.3.2 Static maps

The most common way to distribute geographic information is maps. There are several forms of maps on the Internet. Static maps are not alterable. No geographic processing takes place at static map applications. This approach consists of predesigned map images. These maps are created by using the GIS softwares or graphics softwares. This type is technically simplistic, and it requires the least effort of web browser and user capabilities.

2.3.3 Dynamic maps

Dynamic maps enable to choose features that will be displayed, such as the scale, location etc. In this type of applications, maps are drawn according to preset parameters. And then the web browser displays the map as an image. By changing the parameters, users can generate and view a new map. This type causes heavy load on the server side. It requires programming to provide a map service. It should have a java or activex applet, which extends the browser capabilities. When users visit the site, they are downloaded automatically and temporarily. The alternative is a plug-in approach. Plug-ins must be downloaded and installed like a program. Although they provide a wide variety of map viewing functions, users may not want to spend time or they may not have the experience to download plug-ins.

2.3.4 Query and analysis

This type of accessing data allows users to perform queries and spatial analysis. It provides users capabilities that are found in GIS softwares. Any functions a GIS have, can be performed like data editing or creating. A custom web interface is needed for GIS applications. This category requires effort for programming and a great deal of computer processing.

3. INTERACTIVE EARTHQUAKE INFORMATION ON THE INTERNET

In this study a GIS application was developed and a web site was configured to serve the maps on the Internet. "Interactive Earthquake Information on the Internet" is a software-independent system that enables users to reach spatial information easily.

3.1. Method

In this study, mapping application type is "dynamic web browser". Map parameters are sent by the Internet, and the map image is formed according to setting parameters. In this method, the client side has the web browser only. The server side has geographic data, GIS softwares, and an interface program. Figure 3.1 displays the architecture of the dynamic map browser.

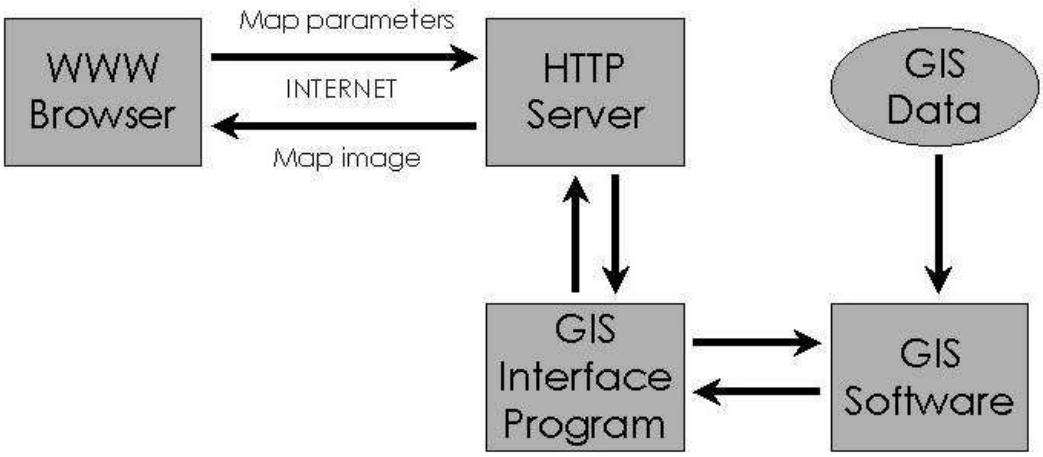


Figure 3.1 Architecture of Dynamic Map Browser.

3.2. Tools

The tools used are "Map Objects" activex software component and "Map Objects Internet Map Server" software. Map Objects was used to build the GIS application and MOIMS was used as a gateway program. Map Objects is an activeX control. ActiveX controls can not be used alone, they should be used with an application development environment. Map Objects and MOIMS were used together with Visual Basic in this project.

Microsoft Personel Web Server Program was used to share information over the Internet. Also Microsoft Internet Transfer Control was used to connect other web servers and retrieve HTML documents.

For the preparation of the spatial data ArcView, ArcInfo, Erdas Imagine, and Microsoft Photoshop programs were used.

3.3. Data Types

Raster and vector, the two types of geographic data were prepared. Raster data is a cellular data structure composed of rows and columns. Vector data represents each feature as a row in a table, and feature shapes are defined by x, y locations in space. In this study, raster data represents topography and population density. Vector data represents earthquakes, map index, provinces, boundries, counties, lakes, rivers, roads.

3.3.1 Raster data

Digital Elevation Model was downloaded from USGS web site. Population data were taken from National Statistic Institute's web site. ArcInfo was used for the main transformations(coordinate, projection), cutting, and selection of the features. ArcView was used for browsing the data, and examining the datasets. For image editing of the raster datasets, Microsoft Photoshop was used.

Digital Elevation Model downloaded from the USGS Web site was in binary format. Binary data were explored with ArcInfo software and exported to cell based grid format. The coordinate system of the downloaded data for topography was geographic coordinate system. The geographical coordinate system is suitable for large areas. But it does not accurately portray the shape of figures. For this reason the Lambert Conformal Conic map projection was selected as the map projection method, which is one of the best for middle latitudes. It maintains distance and direction with minimal distortion of area and shape. Grid data were projected to the Lambert Conformal Conic projection by using image processing software ERDAS Imagine. Table 3.1 shows the projection parameters.

Table 3.1 Lambert Conformal Conic Projection Parameters

Spheroid	International 1909
Datum	European 1950
1st Standard Parallel	37 30 00
2st Standard Parallel	40 30 00
Central Meridian	36 00 00
Reference Latitude	00 00 00
False Easting	1 000 000
False Northing	0.0

Conic projection normally based on two standard parallels. Scale is true along the two selected standard parallels. Standard Parallels are the lines of no distortion. Central meridian is the central line of origin though the area of interest, used in many rectangular coordinate systems to orient the coordinate grid. False easting and false northing are numerical constants used to eliminate negative coordinates in a system, or to change the coordinates to more convenient values.

Grid data were clipped for the study area (Turkey) using ArcInfo software. And then ArcView was used to classify grid data according to its height values. In order to use raster data in MOIMS application, data were converted from grid format to JPEG image format. And then it was converted to TIFF format using Microsoft Photoshop software, because Map Objects displays TIFF format efficiently than JPEG file format. ArcView can not export maps to georeferenced images. Georeferencing requires the data to be placed in a common coordinate system. So the image was georeferenced to the Lambert Conformal Conic projection by using image processing software ERDAS Imagine. Figure 3.2 displays the image after process.

Figure 3.2 Topographic Map.

For the preparation of the population density data, ArcView was used to calculate areas of the boundries and colorize shape file according to population density values. Density display was exported to a JPEG format. JPEG file was converted to a TIFF format. TIFF image file was georeferenced to Lambert Conformal Conic Projection using ERDAS Imagine. Figure 3.3 displays the classified image.

Figure 3.3 Population Density Map.

3.3.2 Vector Data

ArcView shape file data format was selected as the vector data format. Shape files can support point, line, and area (closed loop) features. Shape file stores geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape including a set of vector coordinates. Attributes are held in a dBase format file.

Digital Chart of the World Data were used for vector data (i.e., rivers, lakes). Data were downloaded from http://www.gisdatadepot.com web site. These data were in the shape file format. Figure 3.4 shows the vector data obtained in the shape file format.

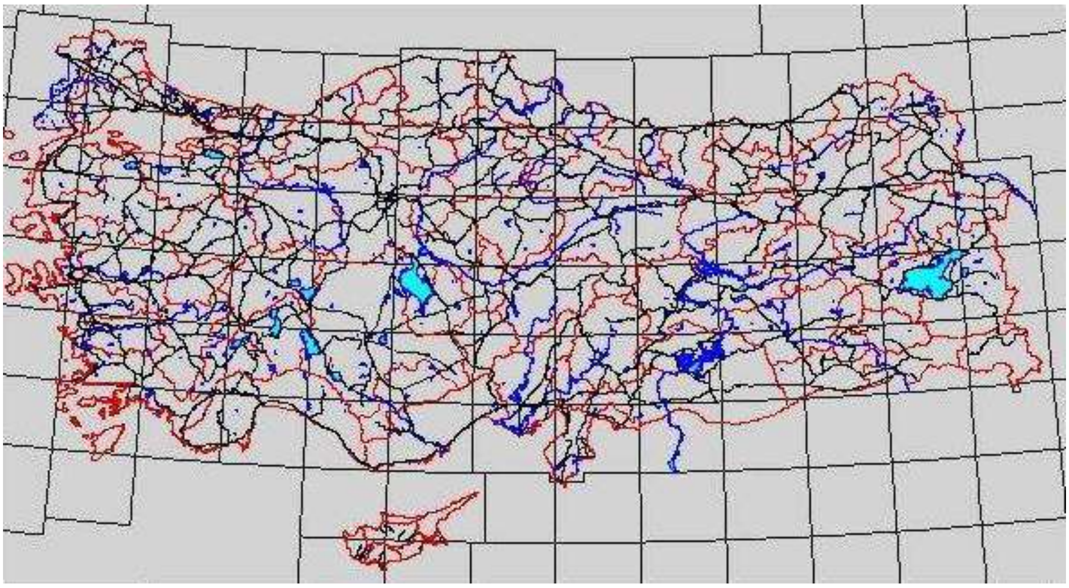


Figure 3.4 Vector Data Display

Earthquake data formatted text file were obtained from Seismology Department of Kandilli Observatory and Earthquake Research Institute. ArcView was used to convert text file to shape file. Attribute information of shape file was also stored in database file. A part of earthquake data in the text file format is displayed at Figure 3.5.

Table 3.2 A Sample of Earthquake Data.

Latitude	Longitude	Magn	Depth	Date	Time
37.800	29.100	5.0	000.00	1900.09.20	00:00:00
37.900	27.900	4.6	015.00	1901.02.23	00:00:00
38.200	27.700	5.0	000.00	1901.03.01	10:00:00
38.400	31.400	5.0	000.00	1901.04.01	00:01:00
38.200	29.600	5.0	000.00	1901.04.01	00:20:00
40.000	44.300	4.1	015.00	1901.04.03	00:57:00
37.800	27.800	5.0	015.00	1901.05.00	00:00:00
39.800	30.500	5.0	015.00	1901.05.12	12:32:00
42.600	43.400	4.5	003.00	1902.03.20	06:10:03
37.800	27.900	4.0	012.00	1902.05.00	00:00:00
37.800	29.100	4.3	015.00	1902.06.21	00:00:00
42.800	44.200	4.7	010.00	1902.07.03	00:00:00
42.600	43.400	3.2	003.00	1902.08.19	02:26:00
40.700	31.600	3.7	000.00	1902.10.00	00:00:00
39.000	28.000	5.5	020.00	1903.04.04	00:00:00
39.100	42.500	6.3	000.00	1903.04.28	23:46:00
38.700	41.500	4.9	000.00	1903.05.03	00:00:00
40.900	42.800	5.4	016.00	1903.05.28	03:54:03
37.800	32.500	4.4	000.00	1903.07.06	00:00:00
41.400	44.500	4.9	000.00	1903.07.08	04:43:00
41.100	44.400	4.5	022.00	1903.07.09	13:21:00
35.000	30.000	5.7	020.00	1903.07.19	18:07:05
42.900	44.700	4.0	008.00	1903.09.02	11:01:00
42.800	44.900	4.4	040.00	1903.10.18	05:18:05
37.800	29.100	4.8	020.00	1904.01.01	11:38:00
40.300	38.400	5.1	000.00	1904.02.16	03:45:00
42.000	41.400	4.2	014.00	1904.04.27	16:06:00
38.400	27.200	5.4	020.00	1904.05.19	10:02:00
37.700	26.900	6.2	006.00	1904.08.11	06:08:00
37.400	26.600	4.5	005.00	1904.08.15	12:12:00
38.000	27.000	6.0	030.00	1904.08.18	20:07:00

All vector data were obtained in the geographic coordinate system. And then they were projected to Lambert Conformal Conic using ArcView.

3.4. Communication Among the Software Components

Map Objects is an ActiveX software component. It is a unit of executable code such as an exe or dll. It provides more functions to form custom mapping applications. Once installed on a system and registered in a development environment such as Visual Basic, Map Objects component can be added to a form and used to develop applications. The most important part about ActiveX control is that they have "properties, events, and methods". Using these tools together increases the power of applications. Properties are the special features about a control. They define the outer view of the control. Methods are the functions that an ActiveX can perform. Events are the user actions that can be made on the control. Following functions can be implemented in programs built with Map Objects control (MO20.ocx):

- Display a map with multiple map layers, such as roads, streams and boundaries.
- Pan and zoom throughout a map.
- Draw graphic features such as points, lines, ellipses, rectangles and polygons.
- Draw descriptive text.
- Identify features on a map by pointing at them.
- Select features along lines and inside boxes, areas, polygons, and circles.
- Select features within a specified distance of other features.
- Select features with an SQL expression.
- Calculate basic statistics on selected features.
- Query and update attribute data associated with selected features.
- Render features with thematic methods such as value maps, class breaks, dot density, charts, events or by Z values.
- Label features with text from field values.
- Create new shape files.
- Draw images from aerial photography or satellite imagery.
- Dynamically display real-time or time-series data.
- Type in an address and find a location on a map.
- Project data into different coordinate systems.

WebLink.ocx is also an ActiveX control. This control is installed automatically with MOIMS. Once added and configured in a development environment such as Visual Basic, its role is to listen on an assigned port for requests from a client and communicate with the esrimap.dll.

Esrimap.dll is a dynamic link library component that extends Web Server Software. It can manage requests and responses from map server and administer map services.

A Visual Basic project was created and Map Objects and WebLink were added to the project to form the application.

The tools used in this study were installed on the server in the following order. First web server software then map server software at last map objects component. Web server software creates a directory and subdirectories on the server for file sharing (drivename:\inetpub\wwwroot\). A web page stored in this directory will be accessed by the users on the network. Map Objects Internet Map Server software creates three executable applications. These are IMS Catalog, IMS Launch, IMS Administrator. Map Objects Internet Map Server acts as a gateway between Web Server and the mapping application. IMS Catalog, IMS Launch and IMS Admin are connected to each other. IMS Admin communicates with IMS Catalog to manage the state of a map service. IMS Catalog communicates with IMS Launch. When starting a map service, IMS Catalog transmits the path and the file name of the map service. IMS Launch responds by starting the map service.

3.5. Work Flow of the Application

When a client sends a URL request to the server that hosts esrimap.dll. Esrimap.dll determines which map service to communicate to respond the request. The URL address :

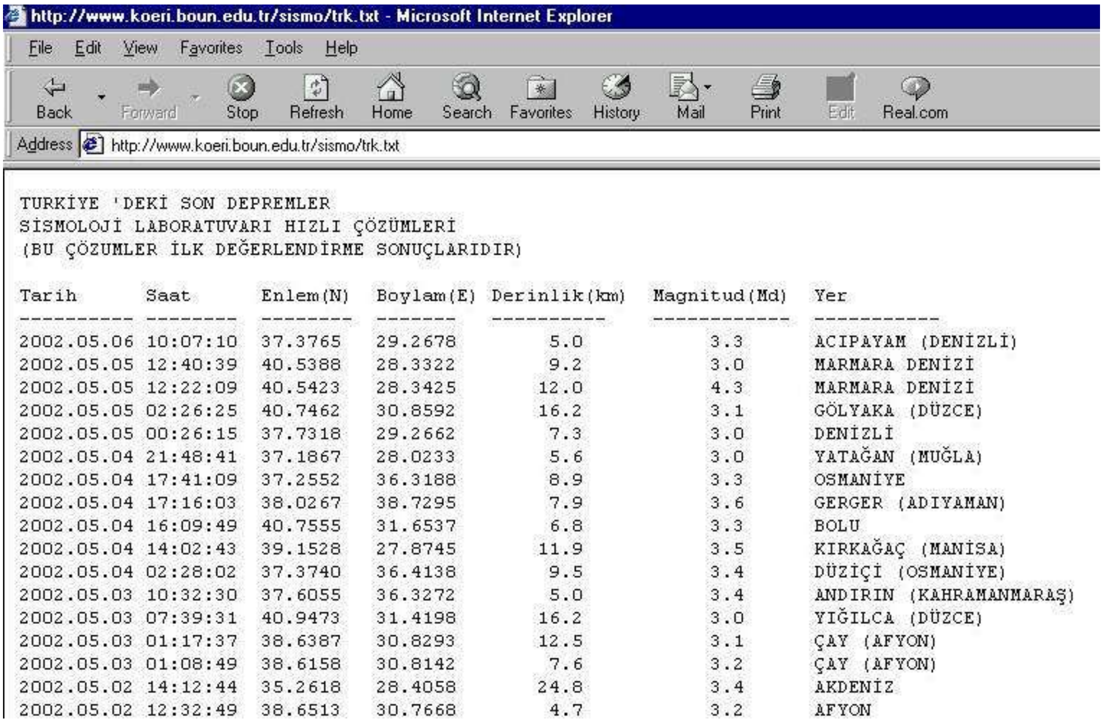
http://ServerName/scripts/esrimap.dll?Name=MapServiceName&Cmd=Map

Each argument and value pair is referred to a query parameter. The first query parameter in the URL is used to determine which application the client wants to communicate. The application name follows the "?" sign. Each argument and value pair is seperated with "&" sign. Arguments and values are used to call the functions that perform specific mapping operations. In this URL address, "Name" is the argument and "MapServiceName" is the value. Arguments transmit the information to the application that which function will be executed by the GIS application. Values are the parameters for these functions.

The GIS application transmits an HTML page to the user for the request. HTML code is generated in the GIS application by using WriteString method of WebLink activex control. Requested map is also sent in HTML code. Before transmitting the map, it is exported to a bitmap image file by Map Objects. Since the bitmap image file format is not a compressed one, it is converted to JPG image file using BMP2JPG method of WebLink activex control.

Microsoft Internet Transfer Control and a Timer Object were also used as components to update the current earthquake information. The timer control that runs at intervals is used to update the current earthquake information. In every ten minutes, the application connects the URL address http://www.koeri.boun.edu.tr/sismo/trk.txt using the Microsoft Internet Transfer Control. After the connection, the text file that contains current earthquake information is downloaded from the web page (Figure 3.5).

The downloaded text file is stored in a string variable. The string variable is examined. Information about each earthquake is stored in an associated string variable. The information includes date, time, latitude, longitude, depth, magnitude and location of the earthquakes. Using this information a new point type geographic dataset is created and the old layer is removed. Point coordinates of the earthquakes are in the geographic coordinate system. They are converted to the Lambert Conformal Conic Projection by using a dll program which was created with C++ programming language before. The projected coordinates are stored in the shape file and attributes are stored in the database table. Earthquake points were symbolized according to their magnitude and depth values. Two types of symbolization are used for the earthquake points. Symbol size of the points represents the magnitude of the earthquakes. Symbol color of the points represents the depth of the earthquakes.



TURKİYE 'DEKİ SON DEPREMLER
SİSMOLOJİ LABORATUVARI HIZLI ÇÖZÜMLERİ
(BU ÇÖZUMLER İLK DEĞERLENDİRME SONUÇLARIDIR)

Tarih	Saat	Enlem(N)	Boylam(E)	Derinlik(km)	Magnitud(Md)	Yer
2002.05.06	10:07:10	37.3765	29.2678	5.0	3.3	ACIPAYAM (DENİZLİ)
2002.05.05	12:40:39	40.5388	28.3322	9.2	3.0	MARMARA DENİZİ
2002.05.05	12:22:09	40.5423	28.3425	12.0	4.3	MARMARA DENİZİ
2002.05.05	02:26:25	40.7462	30.8592	16.2	3.1	GÖLYAKA (DÜZCE)
2002.05.05	00:26:15	37.7318	29.2662	7.3	3.0	DENİZLİ
2002.05.04	21:48:41	37.1867	28.0233	5.6	3.0	YATAĞAN (MUĞLA)
2002.05.04	17:41:09	37.2552	36.3188	8.9	3.3	OSMANİYE
2002.05.04	17:16:03	38.0267	38.7295	7.9	3.6	GERGER (ADIYAMAN)
2002.05.04	16:09:49	40.7555	31.6537	6.8	3.3	BOLU
2002.05.04	14:02:43	39.1528	27.8745	11.9	3.5	KIRKAĞAÇ (MANİSA)
2002.05.04	02:28:02	37.3740	36.4138	9.5	3.4	DÜZİÇİ (OSMANİYE)
2002.05.03	10:32:30	37.6055	36.3272	5.0	3.4	ANDIRIN (KAHRAMANMARAŞ)
2002.05.03	07:39:31	40.9473	31.4198	16.2	3.0	YIĞILCA (DÜZCE)
2002.05.03	01:17:37	38.6387	30.8293	12.5	3.1	ÇAY (AFYON)
2002.05.03	01:08:49	38.6158	30.8142	7.6	3.2	ÇAY (AFYON)
2002.05.02	14:12:44	35.2618	28.4058	24.8	3.4	AKDENİZ
2002.05.02	12:32:49	38.6513	30.7668	4.7	3.2	AFYON

Figure 3.5 Current Earthquakes Data on KOERI Web Page.

The difference between current earthquakes layer and the other layers is that current earthquakes layer is created during the application, the other layers were prepared before.

4. ADDITIONS ON THE STUDY

4.1 Contributes of Disciplines to GIS

GIS is multidisciplinary. It is a convergence of technological fields and traditional disciplines. GIS data come from variety of sources. GIS is developed by association of multiple disciplines such as geodesy, photogrammetry, cartography, statistics, mathematics, computer science, Earth science, and surveying. Each related field provides some of the tecniquies, which form GIS. GIS is used by different constituents, departments, and interest groups. It is possible to make conventional GIS over the Internet sharing various data for the use of the whole world.

4.2 New Geodatasets

In this thesis, new data were added and some existing data were updated (Table 4.1).

Table 4.1 New Geodatasets.

Layers	Process	Feature Type	Symbol Type
Earthquake Record Stations	added	point	rectangle
Fault Lines	added	line	solid
Marmara GPS Stations	added	point	triangle
Displacement Vectors by GPS	added	line	arrow
Historical Earthquakes	updated	point	circle

The historical earthquakes cited in this study are the earthquakes that occured between 1900 and 2002. The earthquakes that occured from the beginning of 2002 until now are named the current earthquakes. The update process was done according to these definitions.

4.2.1. Data acquisition

Coordinates of seismic stations which are spread in Turkey were downloaded from Seismology Department of Kandilli Observatory and Earthquake Research Institute.

Coordinates of strong ground motion stations were obtained from Earthquake Engineering Department of KOERI. In addition, post seismic displacement vectors of Marmara GPS network points were obtained from Geodesy Department of KOERI. Coordinates of fault lines were obtained from Geophysics Department.

4.2.2. Data compilation

For combining multiple files on the same display, data must be in the same spatial reference system. After data were obtained, they were subjected to some process such as coordinate transformation and manipulation.

The number of seismic stations cited in this study are 39. According to their communication types these stations are named broadband, online, and telemetry stations. The number of strong ground motion stations are 13. This information was downloaded from KOERI web site and an ArcView script was written to convert the text file format to shape file format. ArcView scripts are macros written in ArcView's programming language and development environment called Avenue. At the same time the attribute information was stored in the database.

Since the points symbolize the stations and the vectors represent the lines, another ArcView script was used to add displacement vectors by GPS and fault lines.

The coordinate system of the vector data that obtained from different sources was the geographic coordinate system. So data were projected to Lambert Conformal Conic by using ArcView program.

Visual Basic 6.0 was used to add new data and to integrate the new and existing data.

4.3 Structural Base of the Study

In this study single computer configuration was formed. Web server and map server software programs and also Map Objects application were set up in the same computer. PC running Windows 98 was used, which has the following features:

- 600 MHz Pentium III Processor
- 256 MB RAM
- ISDN Internet Connection

4.3.1. Software installations

Personel Web Server program was installed on the server. Web server software created a directory like c:\inetpub\wwwroot\ for file sharing. A web page that is stored in this directory can be accessed by the users on the network. Figure 4.1 displays the personal web manager dialog.

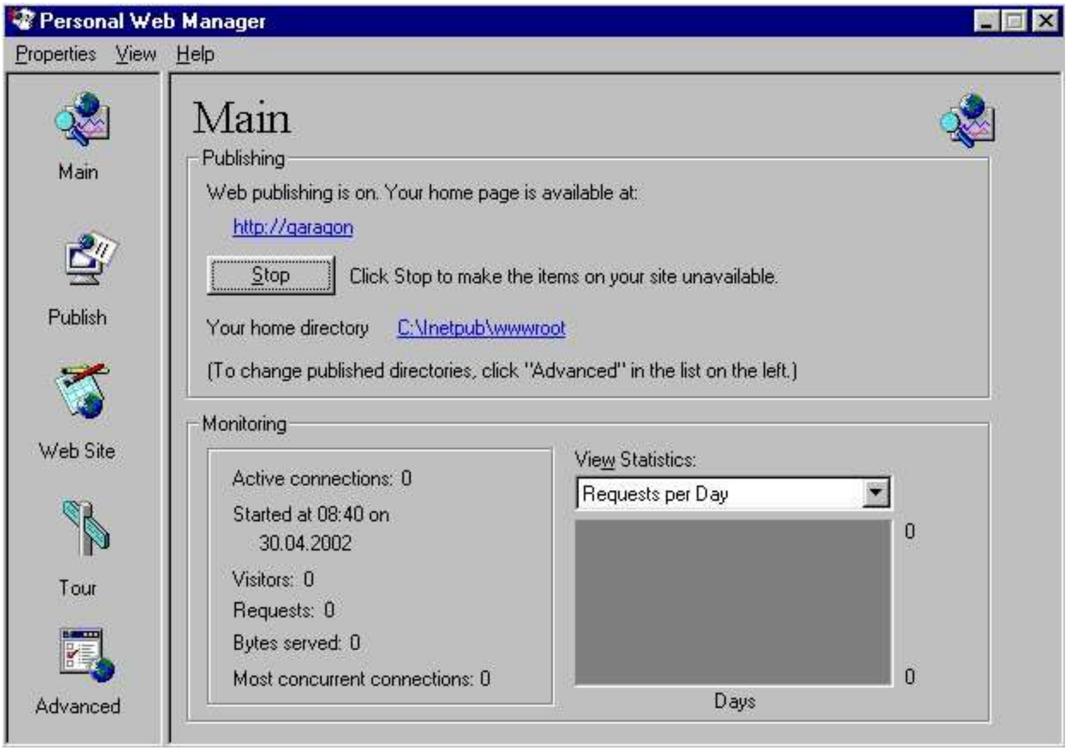


Figure 4.1 Personal Web Manager Dialog.

Then Map Objects Internet Map Server program was installed on the server. Installation creates three executable components: IMS Administrator, IMS Catalog, and IMS Launch. Also when MOIMS was installed on the server, Esrimap.dll that extends the web server software was registered in "c:\inetpub\wwwroot\scripts" directory to manage requests and responses

4.3.2. Setting properties

After the installation of the map server program, host properties were set by using some dialog boxes. When components of the map server program were first started, these dialog boxes appear. IMS Catalog and IMS Launch properties boxes are displayed at Figure 4.2 and Figure 4.3.

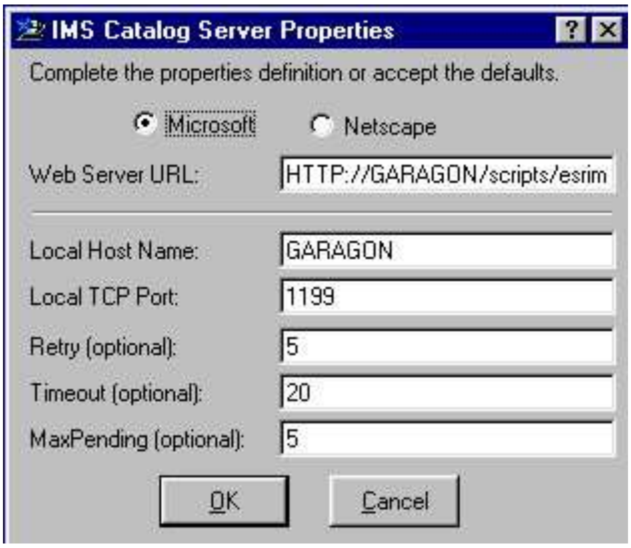


Figure 4.2 IMS Catalog Properties Dialog

Figure 4.3 IMS Launch Properties Dialog

Using these dialog boxes, web server software is selected. Web server URL is the URL of the computer where Esrimap.dll was installed. Local host name is the name of the host computer where IMS Catalog was installed. Local TCP Port sets the TCP/IP address that the communication port listens to. Retry defines the maximum number of times an attempt is made by a client to connect to a map server. Time-out sets the number of seconds a request waits. MaxPending controls the number of requests that can be simultaneously waiting on a map server.

IMS Catalog manages map service registry for the Web site. IMS Catalog uses IMS Launch to start the requested number of map services on a map server.

IMS Admin is interactively used to register and unregister map services with Esrimap.dll and to maintain the list of current services in the IMS Catalog. IMS Admin properties dialog boxes are displayed at Figure 4.4 and Figure 4.5.

Figure 4.4 IMS Admin Web Properties Dialog.

Figure 4.5 Map Objects Web Properties Dialog.

When web server program, catalog, and launch are running, IMS Admin is started and the GIS application is served by the admin. Map service can be operated and stopped by the admin. Map service property settings were done in IMS Admin dialog box (Figure 4.6).

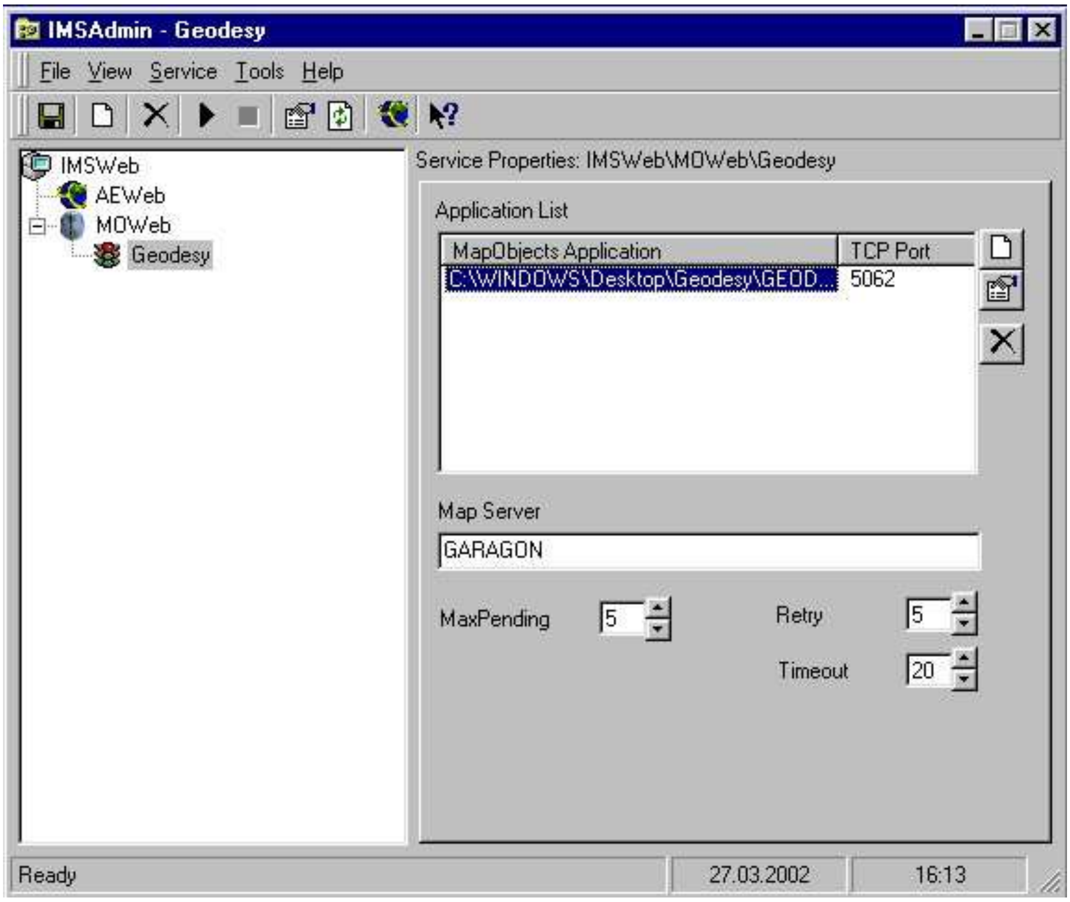


Figure 4.6 IMS Administrator.

4.3.3. Forming application

The GIS application was formed using Visual Basic development environment. First a Visual Basic Project was created, then Map Objects and WebLink ActiveX Controls were added to the project (Figure 4.7).

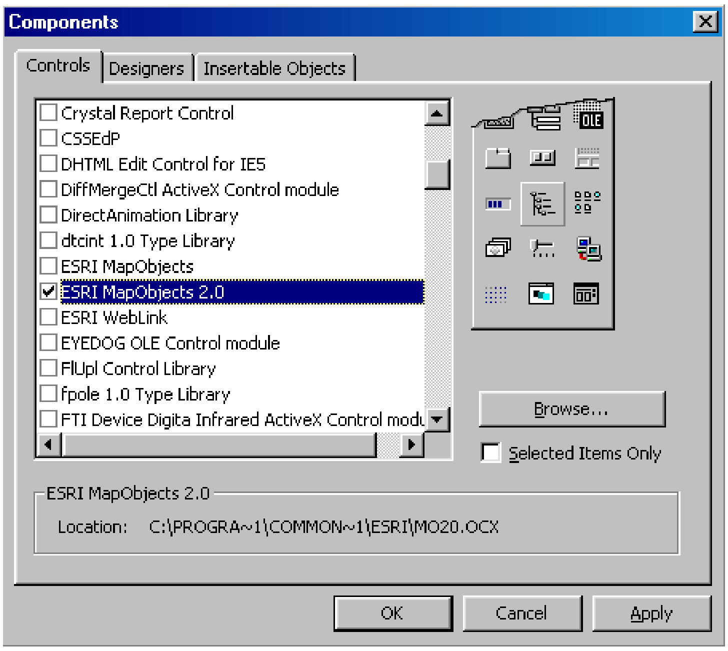


Figure 4.7 Visual Basic Components Dialog

These activex components enable the system to put together sophisticated applications. Figure 4.8 shows the visual basic project.

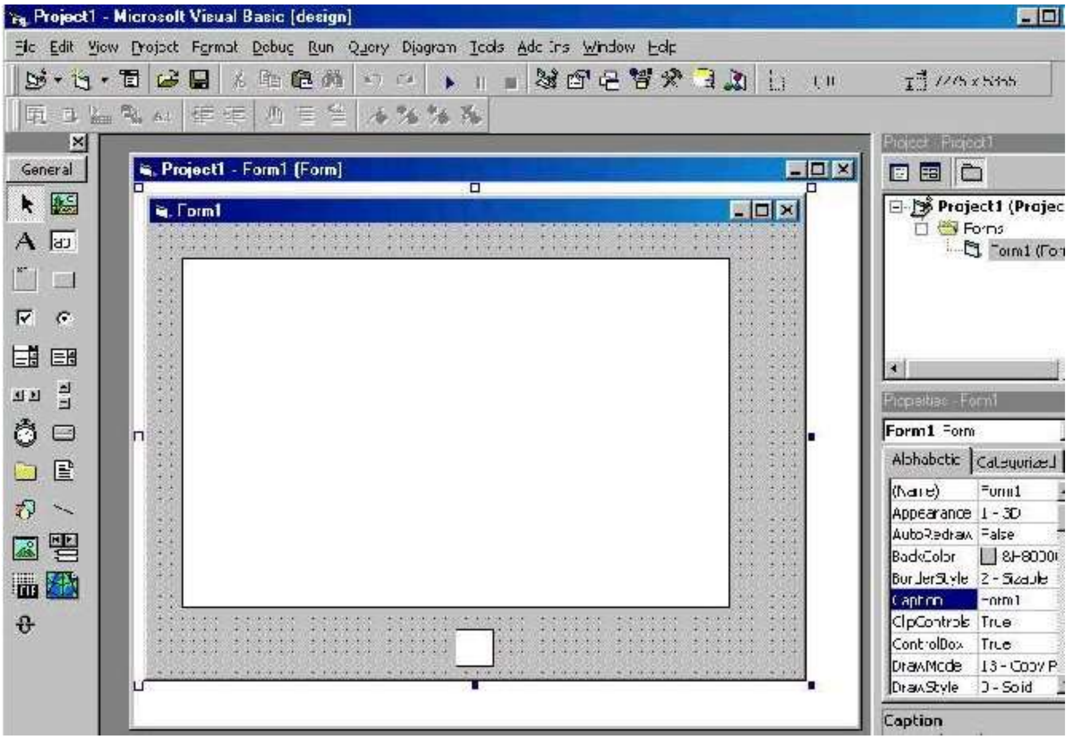


Figure 4.8 Visual Basic Project Display.

Map control was used as a container for the map layers. Map layers are logical sets of thematic data described and stored in a map library. Using properties, methods, and events of map control, GIS application for the web site was created.

The Layers collection includes a MapLayer or an ImageLayer object for each layer defined for a map. There are two ways to add MapLayer to the map control. First is doing right-click on the map control with the mouse and setting parameters by using property pages dialog and layer properties dialog (Figure 4.9 and Figure 4.10).

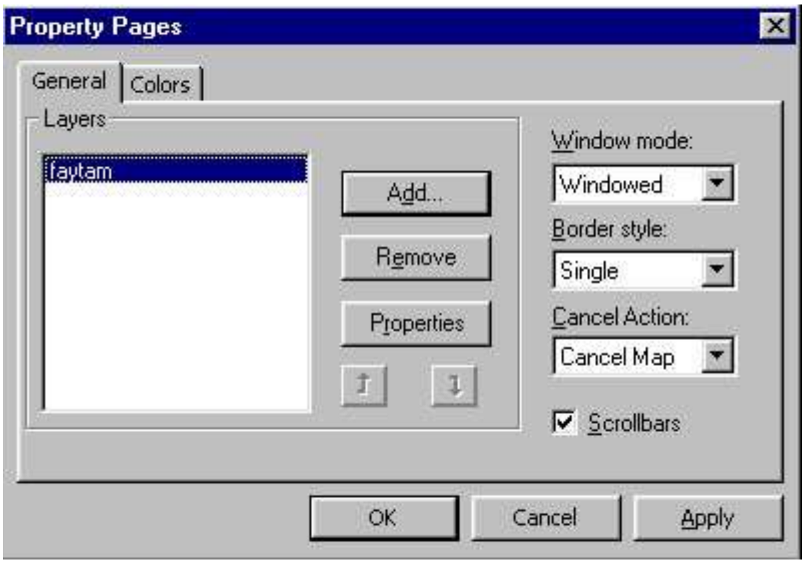


Figure 4.9 Property Page Dialog

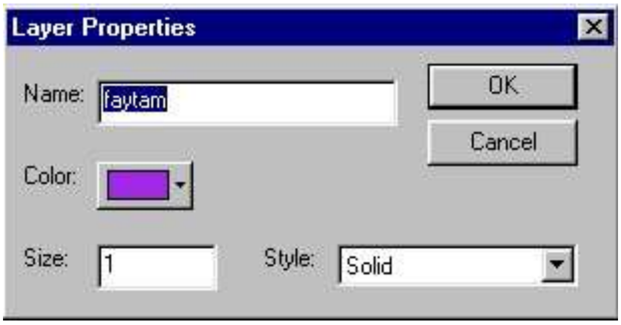


Figure 4.10 Layer Properties Dialog

Second is writing codes. It is more suitable in such an application to add all map layers by writing codes. So new map layers and functions were added to the project by writing codes. Table 4.2 displays a sample of codes that was written to add map layers to map control by using its methods and properties.

Table 4.2 A Sample of Visual Basic Codes.

```
' add shape files
  Dim dc As New DataConnection
  Dim Lyr As MapObjects2.MapLayer

  dc.Database = ImsDataPath
  If Not dc.Connect Then
      MsgBox "ims_data set not found"
      End
  End If
  Set Lyr = New MapLayer
  Set Lyr.GeoDataset = dc.FindGeoDataset("seismic1")
  Lyr.Symbol.SymbolType = moPointSymbol
  Lyr.Symbol.Style = moSquareMarker
  Lyr.Symbol.Color = moRed
  Lyr.Symbol.size = 9
  Lyr.Visible = False
  Map.Layers.Add Lyr
```

Main properties of a map control are :

CoordinateSystem, Extent, FullExtent, MousePointer and Visible.

Main methods of a map control are:

DrawShape, Export Map, Pan, Refresh and TrackRectangle.

Main events of a map control are:

AfterLayerDraw, BeforeLayerDraw, MouseDown and MouseMove.

To add ImageLayer to the map control, ImageLayer objects are created in Visual Basic with code like this:

"Dim ilyr as New MapObjects2.ImageLayer"

An ImageLayer represents a layer that is based on geo-referenced raster data stored in an image file.

In order to add text labels to the map, Label Renderer object of Map Objects is used. A Label Renderer represents a way of symbolizing features by drawing text on a feature. The Field property of Label Renderer object is the name of the Field in the Recordset that stores the text values to use as labels. The Symbol property returns the Text Symbol that is used to draw the text. The Symbol Count property contains the number of symbols associated with the Label Renderer.

Common geometric shapes, such as line, ellipse, rectangle, can be created at any size on the map. The functionality of a geometric object is provided by Map Objects. For instance, a rectangle object represents a geometric shape with four edges and four right angles. Rectangle objects can be created in Visual Basic with code like this:

" Dim rect as New MapObjects2.Rectangle "

A geometric object can be manipulated using its properties and methods.

4.4 Server Side

Server side of the application has an executable file that executes a program. A data path form is generated to set the paths to the directories where data are (Figure 4.11). When the application is operated, the path form appears, with the fields filled with system default values. Figure 4.12 displays the running exe file which is on the server side.

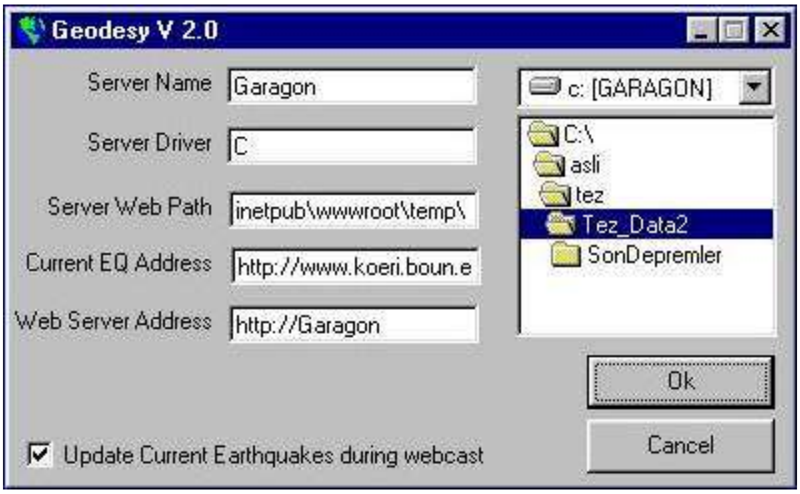


Figure 4.11 Data Path Form on Server Side.

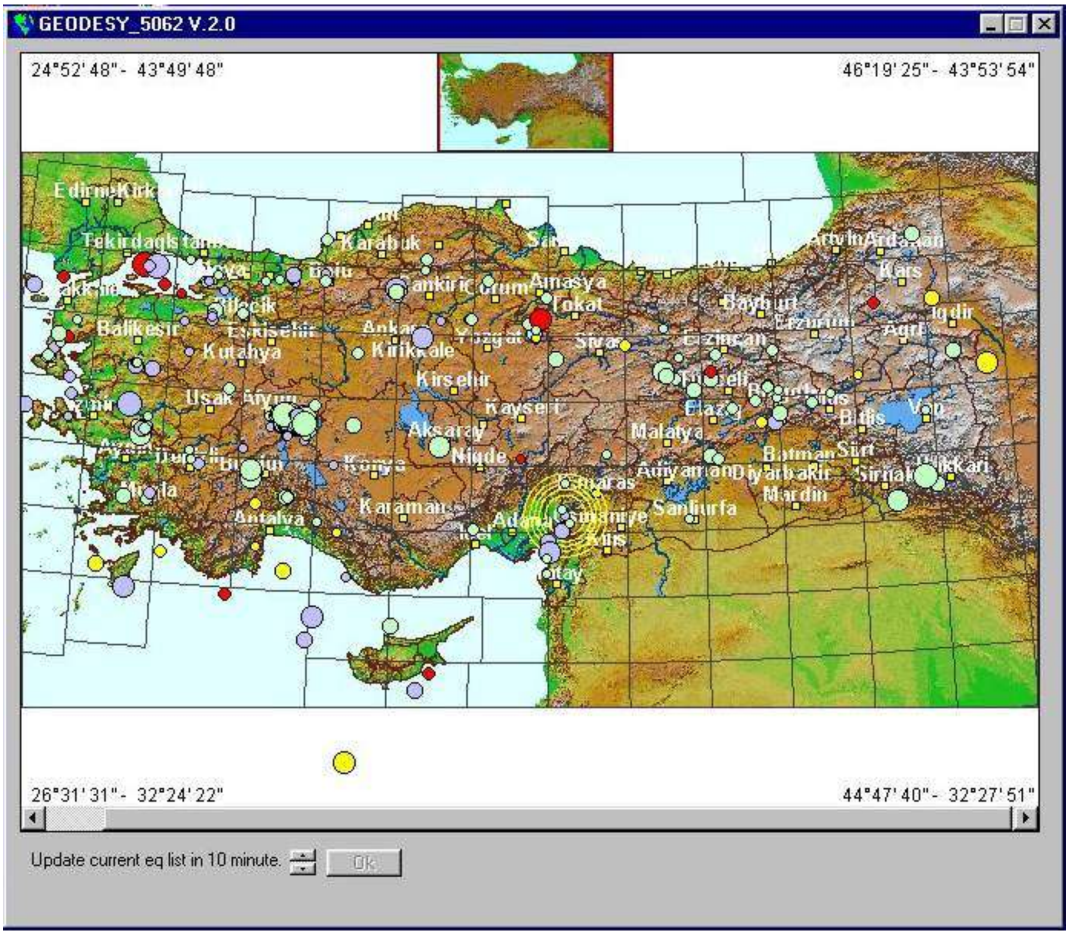


Figure 4.12 Application Form on Server Side.

The update interval for the current earthquakes can be set optionally.

4.5 Specific Operations

On the client side of the application, a standard web browser is adequate only to access the interactive maps. Figure 4.13 displays the web page on the client side.

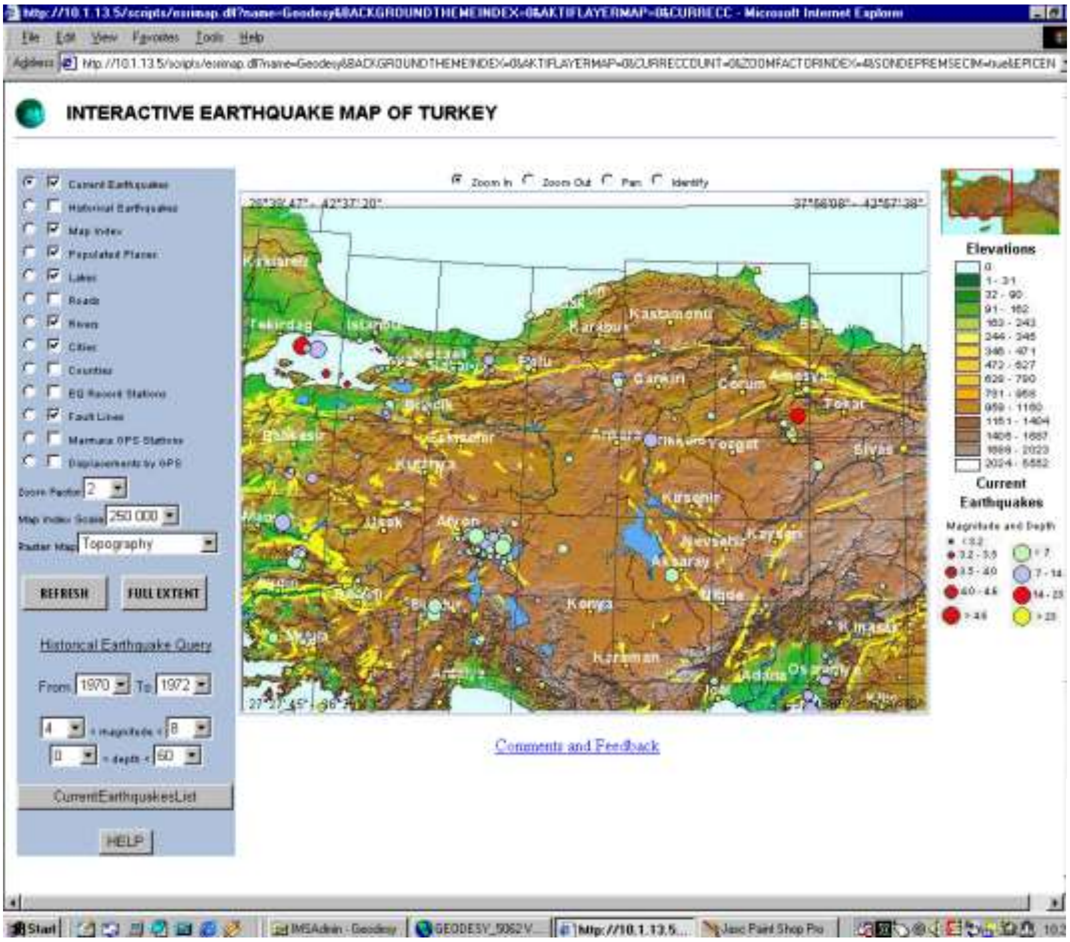


Figure 4.13 Web Page.

The web page contains an interactive map container which displays the map layers, a toolbar column that is used for setting parameters, and a legend column that is an explanatory table of the symbols appearing on the map. Users can use the maps interactively by performing conventional GIS functions such as zoom, pan, identify, and queries. The layers that can be displayed on the map are located on the toolbar column. There are combo boxes, check boxes, and radio buttons on the page. These tools are used for the user interaction.

A spatial query can be done by clicking a feature on the map. An historical query can also be done for the earthquakes by selecting criterias. The criterias are lower and upper values for the year, magnitude, and the depth attributes of the earthquakes (Figure 4.14).

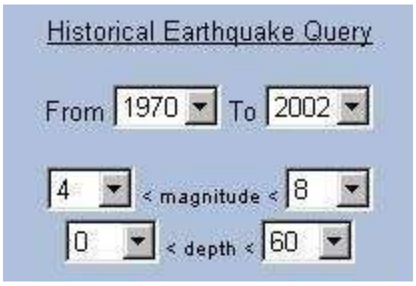


Figure 4.14 Logical Query.

The background can be selected as topographic map or population density map by using the raster map drop-down list box. The content of the legend column changes according to the selected parameters. The refresh button is used to confirm the changes on the parameters. The full extent button is to visualize the whole map. A feedback opportunity is also available on the page. The thumbnail map marks the displayed zone with a red rectangle (Figure 4.15).

Figure 4.15 Thumbnail Map Image

In order to query on a layer, its radio button and the identify radio button is activated. Then a feature related to active layer is clicked on the map. The query results pertaining to the clicked feature will be displayed in a table below the map (Figure 4.16).

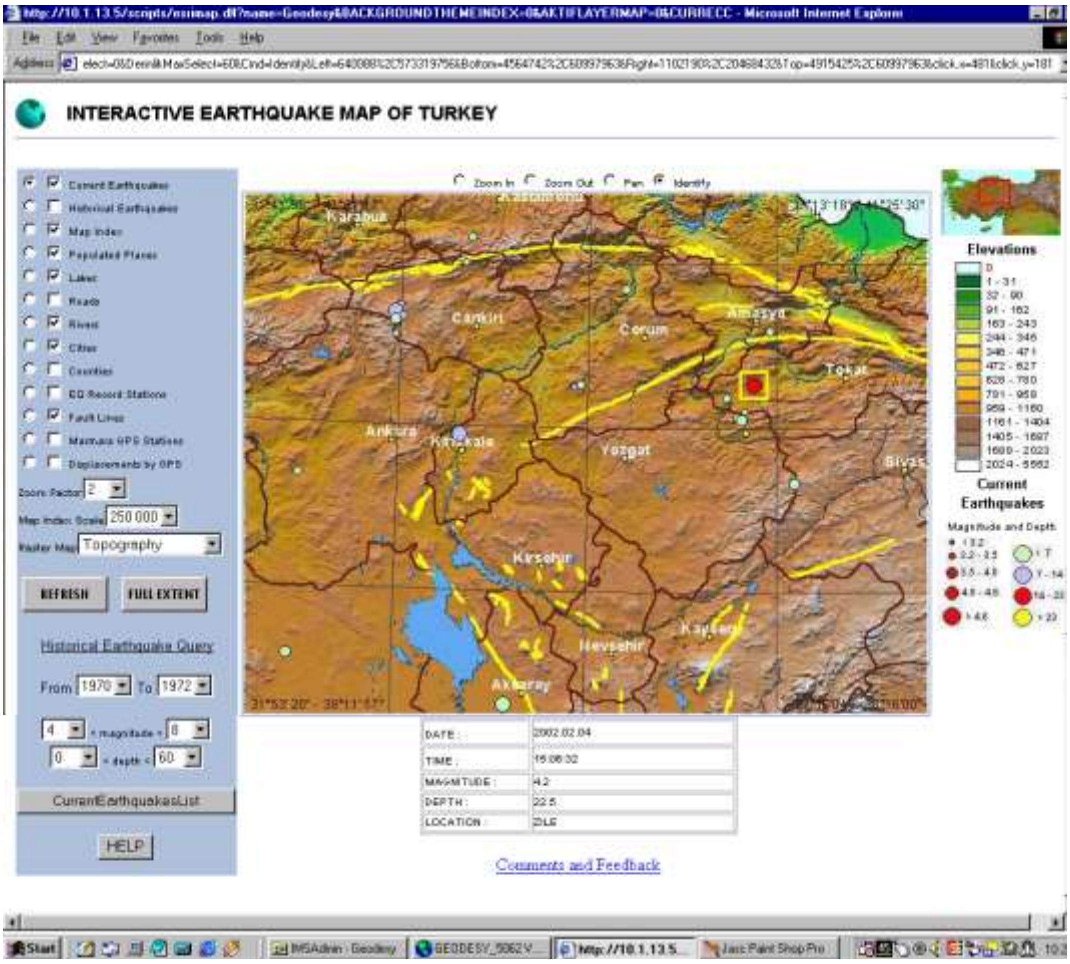


Figure 4.16 Query Results on Current Earthquakes Layer.

Query results table contains location, date, time, magnitude, and depth values for an clicked earthquake point on the map (Figure 4.17).

DATE :	2002.03.26
TIME :	00:38:25
MAGNITUDE :	3
DEPTH :	9.9
LOCATION :	SULAKYURT

Figure 4.17 Query Results Table for Earthquakes Layer.

The map index layer has 1/25000, 1/50000, 1/100000, 1/250000 map partitions. Users can select a partition using map index scale drop-down list box. Figure 4.18 shows another query result display pertaining to the map index layer.

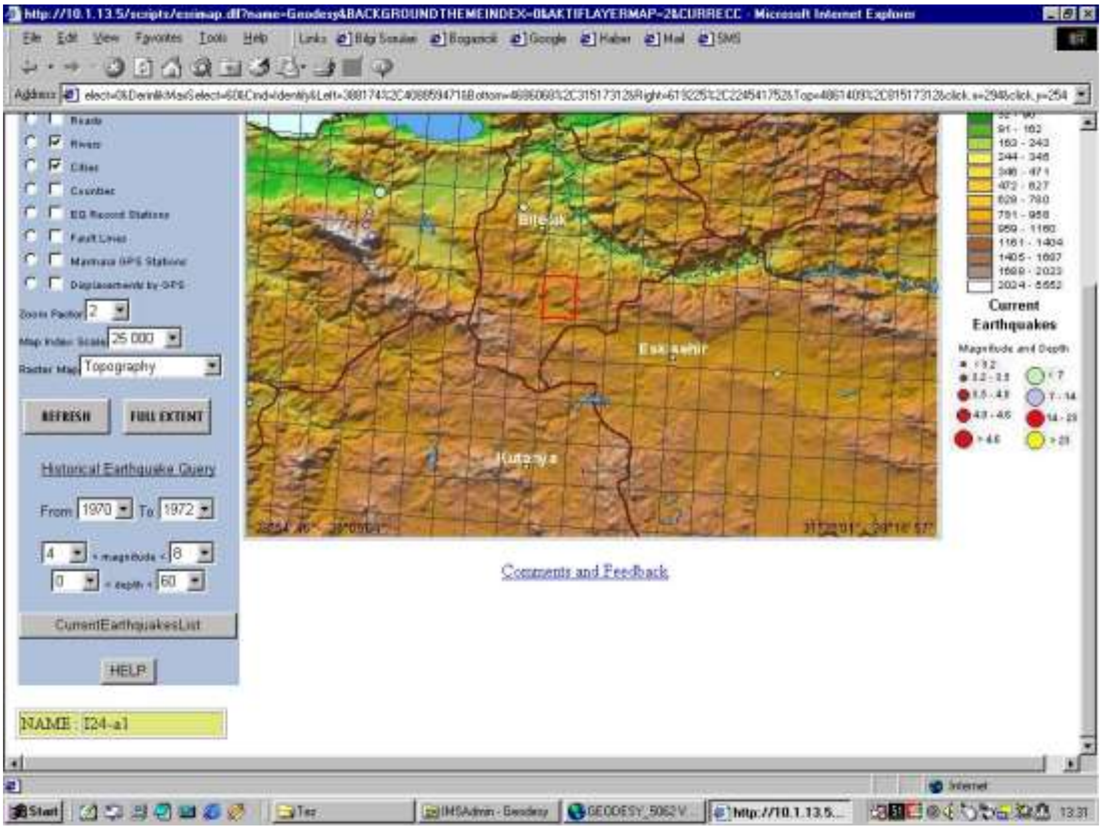


Figure 4.18 Query Result on Map Index Layer.

The query result table contains the 1/25000 map number for the clicked rectangle in Bilecik province boundries (Figure 4.19). Furthermore a red highligt marks the clicked rectangle.

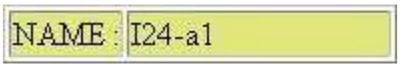


Figure 4.19 Query Result Table for Map Index Layer.

Another query can be performed for the cities or counties layers (Figure 4.20). Query results table for the clicked polygon on the map contains name, population, population density, and area values (Figure 4.21).

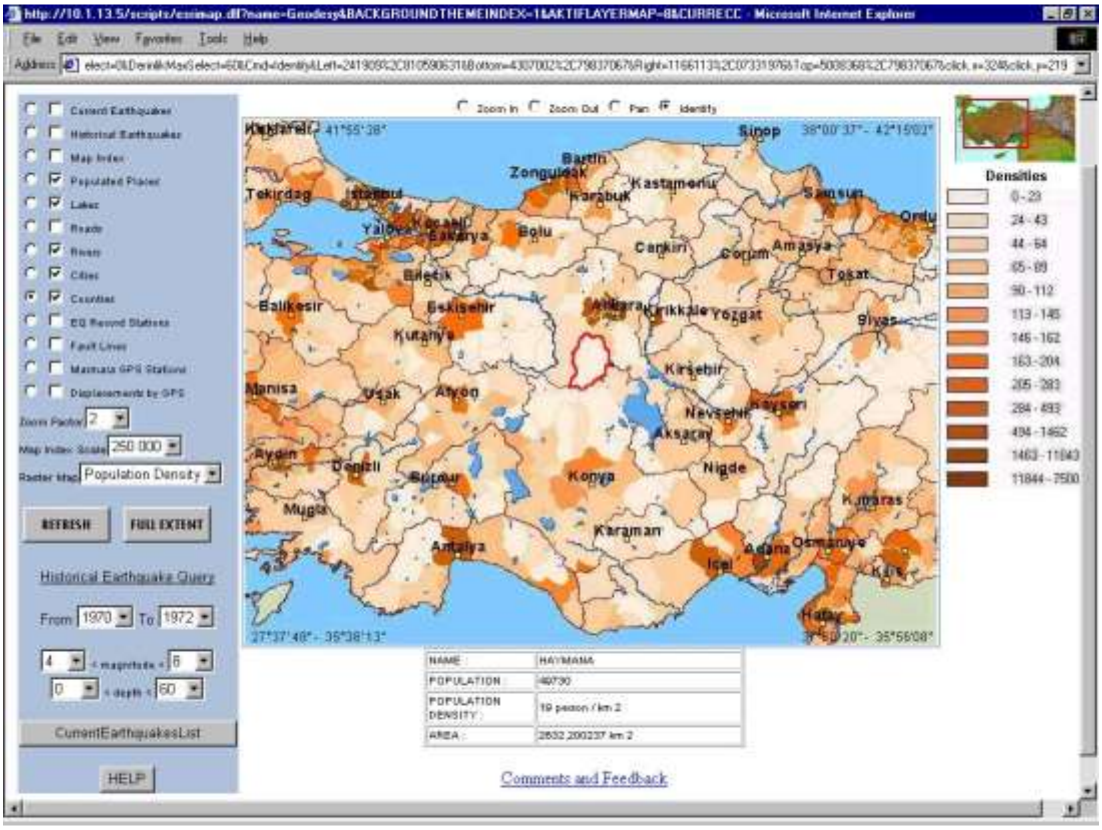


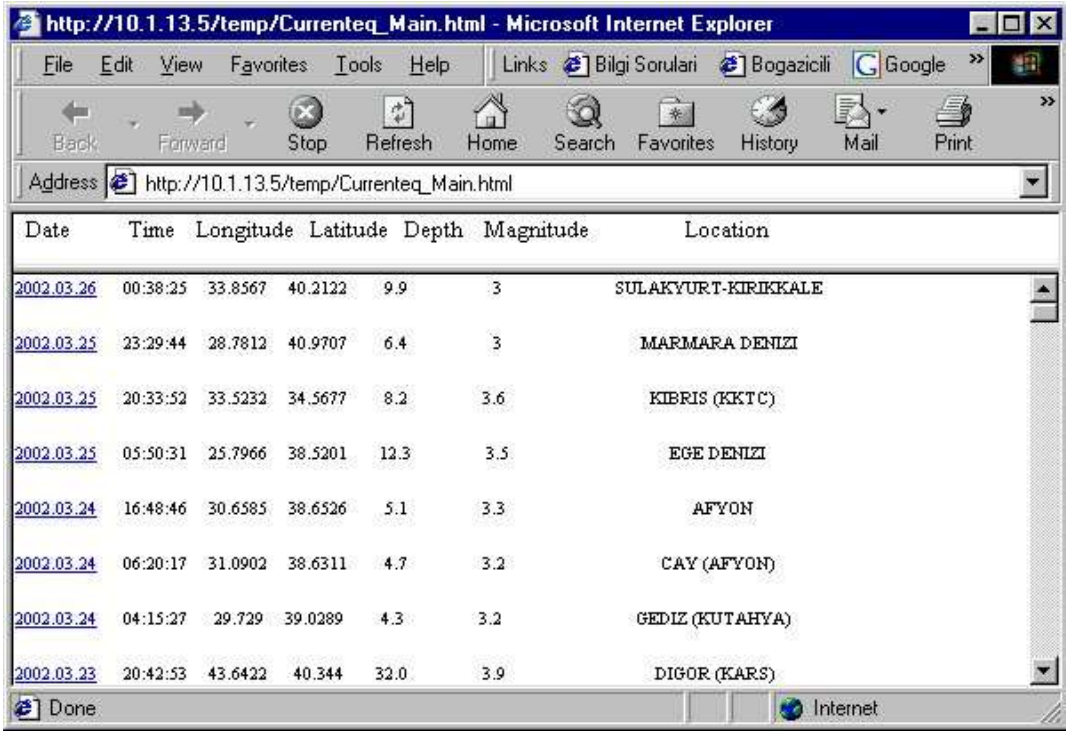
Figure 4.20 Query Results on Counties Layer.

A red highligt marks the clicked polygon.

NAME :	HAYMANA
POPULATION :	49730
POPULATION DENSITY :	19 person / km 2
AREA :	2632,200237 km 2

Figure 4.21 Query Results Table for Counties Layer.

Pressing the Current Earthquakes List button opens a new HTML page for the current earthquakes (Figure 4.22). Each earthquake record has its own hyperlink.



Date	Time	Longitude	Latitude	Depth	Magnitude	Location
2002.03.26	00:38:25	33.8567	40.2122	9.9	3	SULAKYURT-KIRIKKALE
2002.03.25	23:29:44	28.7812	40.9707	6.4	3	MARMARA DENIZI
2002.03.25	20:33:52	33.5232	34.5677	8.2	3.6	KIBRIS (KKTC)
2002.03.25	05:50:31	25.7966	38.5201	12.3	3.5	EGE DENIZI
2002.03.24	16:48:46	30.6585	38.6526	5.1	3.3	AFYON
2002.03.24	06:20:17	31.0902	38.6311	4.7	3.2	CAY (AFYON)
2002.03.24	04:15:27	29.729	39.0289	4.3	3.2	GEDIZ (KUTAHYA)
2002.03.23	20:42:53	43.6422	40.344	32.0	3.9	DIGOR (KARS)

Figure 4.22 List of Current Earthquakes.

Users can receive a new web page clicking these links (Figure 4.23). And the application marks the selected earthquake link on the map.

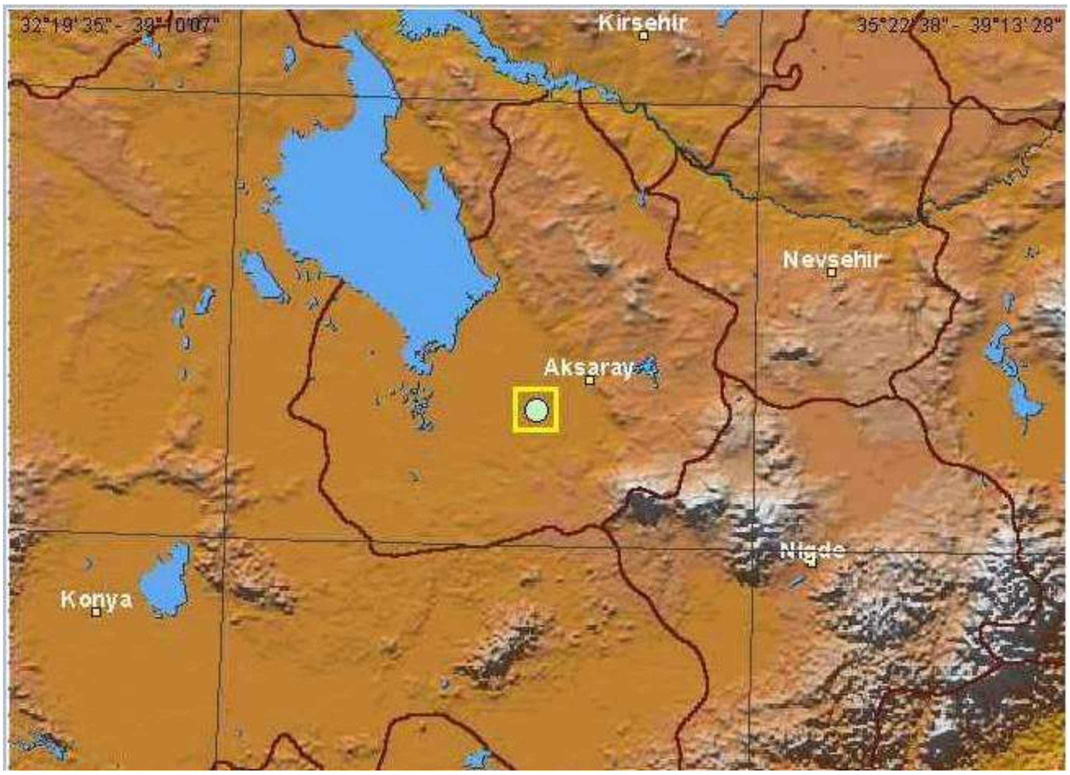


Figure 4.23 Map Image with Marked Earthquake.

Pressing the help button, a new web page is opened. This help page consists of definitions for the functions on the page (Figure 4.24).

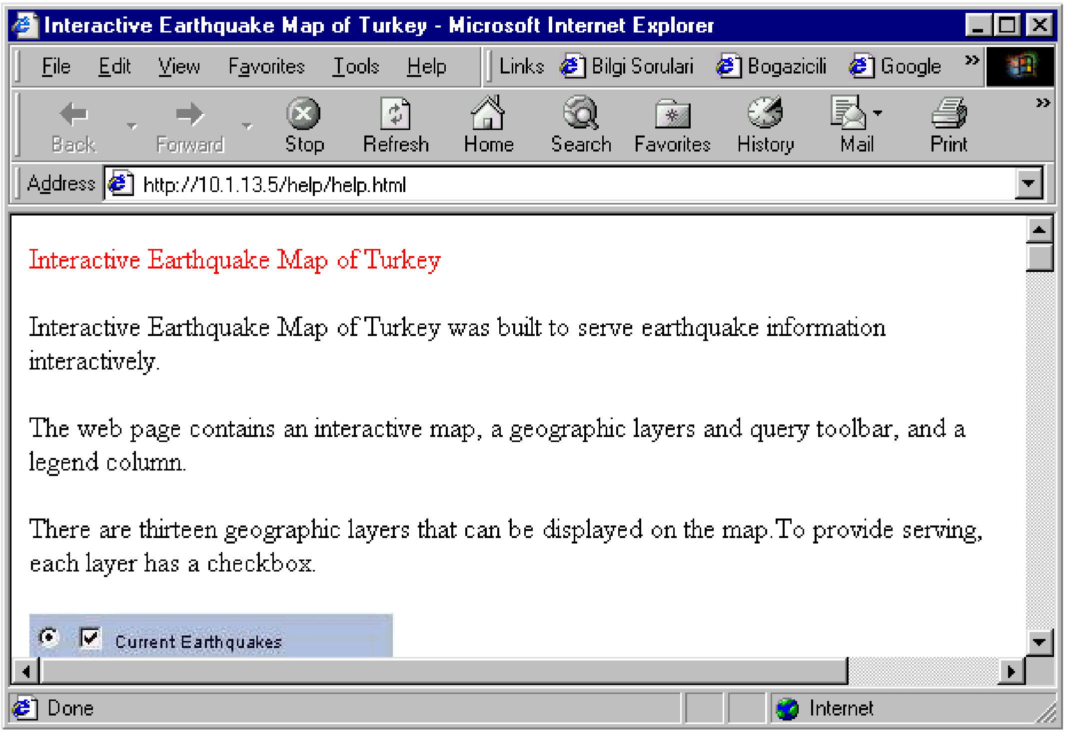


Figure 4.24 Help Page.

CONCLUSIONS AND FUTURE EXTENSIONS

The aim of the study is to comprehend and to enhance the application named Interactive Earthquake Information on the Internet including updating and providing maintenance of the data. This thesis was prepared as a continuation of the existing study.

In this study, a dynamic map browser was formed for the earthquake information. This method provides public users easy access to GIS functions on the Internet with low technological requirements. The application is a software-independent system that users do not have to buy a GIS software and do not have to read manuals to use it but they can access GIS data and analysis functions over the Internet. It offers maximum functionality with the minimum effort. Users can work with the maps interactively by performing conventional GIS functions such as zoom, pan, identify and queries. The maps are alive on the Internet. This method can also incorporate up-to-date, real-time information. Furthermore, the most important characteristic of this study is that earthquake information was located on the geodesic foundation.

In this thesis, new and updated data were prepared and then were inserted into the service. Some changes in the functions were made. For historical query an interval choice was provided. A feedback opportunity was also included in the service. A help page was created to make a simple presentation of the service. The application was formed in English language.

This web page will be published for the public access on the KOERI Geodesy Department Web Site as a map service. A server computer which has high capacity software and hardware is needed for this application. Online GIS is made up of overlapping categories and inter-disciplinary categories. New datasets and functions will be added to the service. A Turkish version of the application will be formed. For downloading function of the spatial data, a login opportunity will be provided.

Online GIS creates new opportunities and challenges. This application may be a stimulus for many advancements, such as disaster management. The future of these technologies are only limited by our own imagination.

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